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Specification

Wireless communication method and wireless communication apparatus

Technical Field

The present invention relates to a wireless communication method for use with a wireless communication system constituted by a plurality of wireless communication apparatuses and to wireless communication apparatuses that composes the wireless communication system.

Background Art

A system constituted by a base apparatus and a display terminal has been developed. The base apparatus functions as an information source or an access point in or to which a television broadcast receiving tuner is built or connected and that is connected to a telephone line through a modem as one type of a wireless LAN system that is structured in a limited area of a residence, an office, or the like. The display terminal executes functions for issuing a command to the base apparatus through a wireless communication with the base apparatus, receiving a picture of the television from the base apparatus, receiving information from the Internet, displaying the picture and information on a display, and transmitting and receiving electronic mail through the base apparatus.

As radio frequency bands that can be used for the wireless communication system, the IEEE 802.11a standard has defined a 5.8 GHz band (in U.S. a 5.2 GHz band, these bands

are generally called 5 GHz band), whereas the IEEE 802.11b standard has defined a 2.4 GHz band.

When a wireless communication system deals with both the 5.2 GHz band and 2.4 GHz band, it can perform a communication on a radio channel (radio frequency) properly selected as a communication channel from the 5.2 GHz band and 2.4 GHz band.

However, in a communicable area of the above-described wireless communication system, another wireless communication system that is the same type as the present system or a different type such as Bluetooth (a registered trademark) that uses the same frequency bands as the present system might coexist.

In addition, if another system coexists with the present system, a communication radio wave of the other system becomes a disturbing wave that might cause data to be broken, moving pictures to be stopped and images to be disturbed with respect to the data transmission in the present system.

Also, besides those wireless communication systems that interfere with the present system, there would be for example microwave ovens and so forth in the vicinity of the present system. When the device radiates a radio wave of the radio frequency band that the present system uses, likewise, the radio wave as a disturbing wave adversely affects the present system.

Furthermore, when a large volume of data such as picture

data from the television and moving picture data of the Internet are transmitted, it would be desirable to increase the data transmission rate.

However, in the 5.2 GHz band defined in the IEEE 802.11a standard, the maximum transmission rate can be increased up to 54 M bps (mega bits/second). In contrast, in the 2.4 GHz band defined in the IEEE 802.11b standard, the transmission rate can be increased up to at most 11 Mbps.

If the transmission rate at which a large volume of data such as picture data and moving picture data is transmitted is low, it might be difficult to securely and smoothly transmit the data on real time basis.

Therefore, the present invention is a wireless communication system that deals with a plurality of communicable frequency bands having different transmission rates so as to allow a large volume of data to be securely and smoothly transmitted on real time basis without a disturbance of another wireless communication system and so forth and abnormalities of stop of a moving picture and a disturbance of an image.

Disclosure of the Invention

A wireless communication method of the present invention is for use with a wireless communication system for performing a communication on a radio channel as a communication channel in a frequency band selected from a plurality of communicable frequency bands having different transmission rates, the wireless communication method

comprising the steps of:

detecting radio channels that are not used in the system and that are free of a disturbing wave transmitted from the outside of the system from the frequency bands in decreasing order from relatively higher transmission rates;

detecting whether or not received field strengths at transmission rates of the detected radio channels exceed a predetermined threshold value in decreasing order from the relatively higher transmission rates; and

starting a communication on a channel having a transmission rate at which the received field strength reaches or exceeds the predetermined threshold value in a manner that a communicable frequency band having a relatively higher transmission rate is prioritized and that an unused channel that is free of a disturbing wave and that has a relatively higher transmission rate in one of the frequency bands is prioritized as a communication channel in accordance with the results of the first and second detecting steps.

In the wireless communication method according to the present invention of the above-described method, a frequency band communicable at a high transmission rate is preferentially selected. A communication is started on a communication channel that is free of a disturbing wave preferentially at a high transmission rate. Therefore, the wireless communication method according to the present invention is capable of securely and smoothly transmitting a large volume of data on real time basis without a disturbance of another wireless communication system and abnormalities of stop of a moving picture and a disturbance of an image.

Brief Description of Drawings

Fig. 1 is a schematic diagram showing an external structure of an example of a display terminal as a wireless communication apparatus.

Fig. 2 is a schematic diagram showing an external structure of an example of a base apparatus as the wireless communication apparatus.

Fig. 3 is a schematic diagram showing a raised state of the display terminal.

Fig. 4 is a functional block diagram showing the example of the structure of the base apparatus as the wireless communication apparatus.

Fig. 5 is a functional block diagram showing the example of the structure of the display terminal as the wireless communication apparatus.

Fig. 6 is a schematic diagram showing a channel structure of a 5.2 GHz band.

Fig. 7 is a schematic diagram showing a channel structure of a 2.4 GHz band.

Fig. 8 is a schematic diagram showing a transmission rate and a modulation system of the 5.2 GHz band.

Fig. 9 is a schematic diagram showing a transmission rate and a modulation system of the 2.4 GHz band.

Fig. 10 is a schematic diagram showing a first half part of an example of a process routine of a setting process performed upon startup of communication.

Fig. 11 is a schematic diagram showing a second half part of the process routine shown in Fig. 10.

Fig. 12 is a schematic diagram showing a first half part of an example of a process routine of a mode setting process for the 5.2 GHz band.

Fig. 13 is a schematic diagram showing a second half part of the process routine shown in Fig. 12.

Fig. 14 is a schematic diagram showing an example of a process routine of a mode setting process for the 2.4 GHz band.

Fig. 15 is a schematic diagram showing a first half part of an example of a process routine of a changing process performed during communication in the 5.2 GHz band.

Fig. 16 is a schematic diagram showing a second half part of the process routine shown in Fig. 15.

Fig. 17 is a schematic diagram showing a first half part of an example of a process routine of a changing process performed during communication in the 2.4 GHz band.

Fig. 18 is a schematic diagram showing a second half part of the process routine shown in Fig. 17.

Fig. 19 is a schematic diagram showing an example of a process routine of a mode changing process performed during communication in the 5.2 GHz band in the case in which a transmission rate is increased.

Fig. 20 is a schematic diagram showing a first half part of an example of a process routine of a mode changing process performed during communication in the 2.4 GHz band in the case in which a transmission rate is decreased.

Fig. 21 is a schematic diagram showing a second half part of the process routine shown in Fig. 20.

Best Mode for Carrying Out the Invention

Next, exemplifying the case in which the present invention is applied to the wireless communication system, which is constituted by the above-described base apparatus and display terminal, an embodiment of the present invention

will be described.

[External structures of display terminal and base apparatus: Fig. 1 to Fig. 3]

Fig. 1 shows an external structure of an example of the display terminal and Fig. 2 shows an external structure of an example of the base apparatus.

As shown in Fig. 1, an LCD (Liquid Crystal Display) 51 is disposed at the front of a display terminal 50. A touch panel 53 is disposed on a display screen of the LCD 51. Speakers 55 are disposed at an upper left position and an upper right position of the LCD 51. Plain antennas 89a, 89b for performing a wireless communication with the base apparatus 10, which will be described later, are disposed at a lower left position and a lower right position of the LCD 51.

The antenna 89a is used for a frequency band Ba (5.2 GHz band), whereas the antenna 89b is used for a frequency band Bb (a 2.4 GHz band). The left side antenna forms a semi-spherical surface radiation pattern in the forward direction of the display terminal 50. On the other hand, the right side antenna forms a semi-spherical surface radiation pattern in the backward direction of the display terminal 50. One of the antennas that actually transmits and receives a radio wave is selected in accordance with reception level information of the left side antenna and right side antenna. As a combination of the left side antenna and right side antenna, an antenna that has all spherical surface radiation pattern is formed. Regardless of the relation of positions of the display terminal 50 and base apparatus 10, a wireless

communication between the display terminal 50 and the base apparatus 10 is securely performed.

Below the speaker 55 on the right side of the front of the display terminal 50, an index button 57a, a jump button 57b, and channel buttons 57c, 57d are disposed.

By pressing the index button 57a, it causes an index screen as shown in the drawing to be displayed on the LCD 51. By touching any item of the menu on the index screen with a touch pen or user's finger, he or she can select for example a channel of the television, operate an external device that is connected to the base apparatus 10, access the Internet, create and transmit mail, create and display an album.

By pressing the jump button 57b, it allows an immediately preceding television channel to be received. By pressing the channel button 57c, it causes the current mode displayed on the LCD 51 to be switched in the order from television → external device → Internet → mail → album → television. By pressing the channel button 57d, it causes the operation screen displayed on the LCD 51 to be switched in the reverse order.

An album is a picture or the like that is captured by a digital camera and recorded on a the memory card 77 and then displayed on the LCD 51, processed on the LCD 51, and attached to mail created on the LCD 51. Alternatively, an album is a picture that is stored in the display terminal 50 or the memory card 77, a picture of which a television picture is captured as a still picture, a picture received by mail, a

picture obtained from the Internet, or the like.

On an upper surface of the display terminal 50, a groove portion 69 and so forth are formed. The groove portion 69 accommodates a touch pen 59. On the left, a knob 91 and so forth are disposed. The knob 91 adjusts the brightness of the LCD 51. On the right, a slot 79 and so forth are formed. In the slot 79, the memory card 77 is attached. At the bottom, charging terminals 94, 96 are disposed.

At a the back surface of the display terminal 50, a U-shaped stand 99 that causes the display terminal 50 to be raised is extensively and contractively disposed. A battery accommodating portion (not shown) is disposed at a portion surrounded by the stand 99. A battery is accommodated in the battery accommodating portion.

As shown in Fig. 2, the base apparatus 10 is constituted by a front portion 12 and a rear portion 14 that are integrally connected. At left and right positions of the front portion 12, plain antennas 49a, 49b for performing a wireless communication with the display terminal 50 are disposed.

Like the antennas 89a, 89b of the display terminal 50, the antenna 49a is used for the frequency band Ba (5.2 GHz band), whereas the antenna 49b is used for the frequency band Bb (2.4 GHz band). The left side antenna forms a semi-spherical surface radiation pattern in the forward direction of the base apparatus 10. The right side antenna forms a semi-spherical surface radiation pattern in the backward direction of the base apparatus 10. In accordance

with reception level information of the left side antenna and the right side antenna, one of the antennas that actually transmits and receives a radio wave is selected. As a combination of the right side antenna and left side antenna, an antenna that has a half-spherical surface radiation pattern is formed. Regardless of the relation of the positions of the base apparatus 10 and the display terminal 50, a wireless communication can be securely performed between the base apparatus 10 and the display terminal 50.

The front portion 12 is slanted backwards and, in a lower center portion thereof, a supporting member 16 that causes the display terminal 50 to be inclined against the base apparatus 10 is disposed. Charging terminals 24, 26 are disposed in the supporting member 16. In addition, at a lower portion on the rear surface of the rear portion 14, various types of terminals such as an antenna terminal and a line terminal that will be described later are disposed.

With respect to the above-described base apparatus 10 and display terminal 50, the user can fixedly place the base apparatus 10 at a proper position and carry the display terminal 50 to any place inside a communicable area thereof. The user can execute functions for receiving a television broadcast, accessing the Internet, and transmitting and receiving electronic mail with the display terminal 50 that he or she is holding at any place.

In such case, the user can operate the display terminal 50 with his or her hand but, alternatively, with the stand 99 extended as shown in Fig. 3, the display terminal 50 can

be raised on a proper surface at a properly inclined angle.

In addition, the display terminal 50 may be inclined against the front portion 12 of the base apparatus 10. In this case, the charging terminals 94, 96 of the display terminal 50 are brought into contact with the charging terminals 24, 26 of the base apparatus 10 and they are connected. As a result, the battery accommodated in the display terminal 50 can be charged by the base apparatus 10.

[Functional Blocks of structures of base apparatus and display Terminal: Fig. 4 and Fig. 5]

Fig. 4 shows functional blocks of an example of a structure of the base apparatus 10. A controlling portion 30 comprises a CPU 31. The CPU 31 is connected to a bus 33. A program executed by the CPU 31, fixed data, and so forth is written to a memory 35 in advance. The memory 35 also functions as a work area and so forth of the CPU 31. The memory 35 is connected to the bus 33.

An antenna 1 for receiving a television broadcast is connected to an antenna terminal 11. A television broadcast signal that is received by the antenna 1 is channel-selected and demodulated by a tuner 21. The channel-selected and demodulated signal is compressed and further converted into video data and audio data. The video data and audio data are sent to the bus 33.

A telephone line 3 is connected to a line terminal 13. The line terminal 13 is connected to the bus 33 through a modem 23.

In addition, an Ethernet (registered trademark) terminal 15 for connecting an ADSL modem, a CATV modem, or the like is connected to the bus 33 through an interface 25.

A DVD player, a hard disk recorder, a digital CS tuner, or the like is connected as external device 7 to a terminal 17 for connecting an external device. Video data and audio data from the external device 7 are sent to the bus 33 through an interface 27.

In addition, an AV mouse 9 is connected to a terminal 19. The terminal 19 is connected to the bus 33 through an interface 29. An infrared ray remote control signal is irradiated from a light emitting portion of the AV mouse 9 in accordance with a command signal that is output from the controlling portion 30 and received by a light detecting portion disposed in the external device 7. As a result, with the infrared ray remote control signal, the external device 7 is operated.

On the other hand, BBPs (Base Band Processors) 41a, 41b for the frequency bands Ba, Bb are connected, respectively, to the bus 33. Transmitting and receiving portions 45a, 45b for the frequency bands Ba, Bb are connected to the BBPs 41a, 41b, respectively. The above-described antennas 49a, 49b are connected to the transmitting and receiving portions 45a, 45b, respectively.

Also, disturbing wave detecting portions 43a, 43b are connected between the BBPs 41a, 41b and the bus 33,

respectively. Received field strength detecting portions 47a, 47b are connected between the transmitting and receiving portions 45a, 45b and the bus 33, respectively. The disturbing wave detecting portions 43a, 43b detect whether or not a disturbing wave exists on a radio channel selected from the frequency bands Ba, Bb, respectively, by a method that will be described later. The received field strength detecting portions 47a, 47b detect the received field strengths of the signals received by the transmitting and receiving portions 45a, 45b in accordance with control levels of an AGC (Automatic Gain Control) against the signals received by the transmitting and receiving portions 45a, 45b, respectively.

A signal that is transmitted from the base apparatus 10 to the display terminal 50 is processed for a baseband by the BBPs 41a, 41b and then modulated by the transmitting and receiving portions 45a, 45b, respectively. The modulated signal is converted into a signal of a radio channel selected from the frequency bands Ba, Bb. Thereafter, the radio channel signal is transmitted from the transmitting and receiving portions 45a, 45b to the display terminal 50 through the antennas 49a, 49b, respectively.

In addition, a signal of a radio channel selected from the frequency bands Ba and Bb and transmitted from the display terminal 50 to base apparatus 10 is received by the transmitting and receiving portions 45a, 45b through the antennas 49a, 49b, respectively. The received signal is frequency converted by the transmitting and receiving portions 45a, 45b, respectively. Thereafter, the frequency

converted signal is processed for a baseband by the BBPs 41a, 41b and then received by the bus 33.

Fig. 5 shows functional blocks of an example of a structure of the display terminal 50. A controlling portion 70 comprises a CPU 71. The CPU 71 is connected to a bus 73. A program executed by the CPU 71, fixed data, and so forth is written to a memory 75 in advance. The memory 75 also functions as a work area and so forth of the CPU 71. The memory 75 is connected to the bus 73.

The LCD 51 is connected to the bus 73 through a display controlling portion 61. A speaker 55 is connected to the bus 73 through a DAC (D/A converter) 65 and an audio amplifying circuit 66. In addition, the touch panel 53 is connected to the bus 73 through a coordinate detecting portion 63. Moreover, a key operation portion 57 including the index button 57a shown in Fig. 1 is connected to the bus 73 through an interface 67.

When the memory card 77 is attached to the slot 79 shown in Fig. 1, the memory card 77 is connected to the bus 73.

In addition, BBPs 81a, 81b for the frequency bands Ba, Bb, respectively, are connected to the bus 73. Transmitting and receiving portions 85a, 85b for the frequency bands Ba, Bb are connected to the BBPs 81a, 81b, respectively. The above-described antennas 89a, 89b are connected to the transmitting and receiving portions 85a, 85b, respectively.

In addition, disturbing wave detecting portions 83a,

83b are connected between the BBPs 81a, 81b and the bus 73, respectively. Received field strength detecting portions 87a, 87b are connected between the transmitting and receiving portions 85a, 85b and the bus 73, respectively. The disturbing wave detecting portions 83a, 83b detect whether or not a disturbing wave exists on a radio channel selected from the frequency bands Ba, Bb, respectively, by a method that will be described later. The received field strength detecting portions 87a, 87b detect the received field strengths of signals received by the transmitting and receiving portions 85a, 85b in accordance with control levels of the AGC (Automatic Gain Control) against signals received by the transmitting and receiving portions 85a, 85b, respectively.

A signal that is transmitted from the display terminal 50 to base apparatus 10 is processed for a baseband by the BBPs 81a, 81b and then modulated by the transmitting and receiving portions 85a, 85b, respectively. Thereafter, the modulated signal is converted into a signal of a radio channel selected from the frequency bands Ba, Bb. The signal of the radio channel is transmitted from the transmitting and receiving portions 85a, 85b to the base apparatus 10 through the antennas 89a, 89b, respectively.

In addition, a signal of a radio channel selected from the frequency bands Ba and Bb is transmitted from the base apparatus 10 to the display terminal 50. The signal is received by the transmitting and receiving portions 85a, 85b through the antennas 89a, 89b, respectively. The received signal is frequency converted and demodulated by the

transmitting and receiving portions 85a, 85b, respectively. Thereafter, the demodulated signal is processed for a baseband by the BBPs 81a, 81b and then received by the bus 73.

[Radio frequency bands, radio channels, and transmission rates: Fig. 6 to Fig. 9]

The above-described wireless communication system uses the 2.4 GHz band and the 5.2 GHz band that have been defined in the IEEE 802.11a standard and the IEEE 802.11b standard as the frequency bands Ba and Bb, respectively.

It has been defined that when a plurality of radio channels are set in the 5.2 GHz band and 2.4 GHz at the same time in the same area, as shown in Fig. 6 and Fig. 7, frequency intervals of adjacent radio channels should be apart from each other by 20 MHz or more and 25 MHz or more so as to prevent a signal of one radio channel from becoming a disturbing wave against a signal of the other radio channel, respectively.

Therefore, the number of radio channels that can be set at the same time in the 5.2 GHz band is a maximum of four channels as designated by C1, C2, C3, and C4 shown in Fig. 6 and that in the 2.4 GHz band is a maximum of three channels as designated by C5, C6, and C7 shown in Fig. 7.

The transmission rates and modulation systems in the 5.2 GHz can be set in eight modes A1 to A8 shown in Fig. 8 and those in the 2.4 GHz band in four modes B1 to B4 shown in Fig. 9. However, the names "modes A1 to A8" and "modes B1 to B4" have not been defined in the IEEE 802.11a standard

and the IEEE 802.11b standard, but conveniently defined in this specification.

Modulation systems BPSK, QPSK, QAM, and CCK stand for BPSK: Binary Phase Shift Keying, QPSK: Quadrature Phase Shift Keying, QAM: Quadrature Amplitude Modulation, and CCK: Complementary Code Keying.

However, the modulation systems shown in Fig. 8 and Fig. 9 are multi-value digital modulation (primary modulation) systems for the BBPs 41a and 41b of the base apparatus 10 and the BBPs 81a and 81b of the display terminal 50, respectively. OFDM (Orthogonal Frequency Division Multiplex) is used as the radio frequency modulation for the frequency band Ba of the transmitting and receiving portion 45a of the base apparatus 10 and the transmitting and receiving portion 85a of the display terminal 50. DS (Direct Sequence) is used as the radio frequency modulation for the frequency band Bb of the transmitting and receiving portion 45b of the base apparatus 10 and the transmitting and receiving portion 85b of the display terminal 50.

The transmission rate of the mode B4 in the 2.4 GHz band can be higher than that of each of the modes A1 and A2 in the 5.2 GHz band as shown in the Fig. 8 and Fig. 9. As a whole, the transmission rate in the 5.2 GHz band can be higher than that in the 2.4 GHz band.

[Setting process performed upon startup of communication: Fig. 10 and Fig. 11]

In the state that the power of the base apparatus 10

has been turned on in the above-described wireless communication system, when the user turns on the power of the display terminal 50 and performs an operation for receiving a television broadcast or an operation for accessing the Internet with the display terminal 50, a connection request and a command are transmitted from the display terminal 50 to the base apparatus 10 as signals of a predetermined radio channel of a predetermined frequency band.

After the connection request and command have been received by the base apparatus 10 and the operation for receiving a television broadcast or the operation for accessing the Internet have been performed, a communication with the display terminal 50 is started as follows. Data of a picture and audio of the television, information of the Internet, and so forth is transmitted from the base apparatus 10 to the display terminal 50.

Fig. 10 and Fig. 11 show an example of a process routine of a setting process for a communication frequency band, a communication channel, and a transmission rate that the controlling portion 30 (CPU 31) of the base apparatus 10 executes.

First of all, in step 101 of process routine 100, the controlling portion 30 determines whether or not an unused channel exists in the frequency band Ba (5.2 GHz band) in which a high transmission rate can be set.

While a communication is being performed between the base apparatus 10 and a display terminal of the same type as

the display terminal 50 on a radio channel designated by C1 to C4 as a communication channel in the frequency band Ba, the radio channel is not an unused channel. An unused channel is a radio channel that is not used as a communication channel in the present system.

When the controlling portion 30 has determined that an unused channel exists in the frequency band Ba in step 101, the flow advances to step 102. In step 102, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel in accordance with the detected result of the disturbing wave detecting portion 43a for the frequency band Ba.

A disturbing wave is a communication radio wave transmitted from a wireless communication system that is same type as or different from the present system or a radio wave transmitted from a non-wireless communication apparatus such as a microwave oven.

When determining whether or not a signal received by the transmitting and receiving portion 45a is a disturbing wave, the disturbing wave detecting portion 43a and the controlling portion 30 detect whether or not transmission destination address information is contained in a received signal that has been processed in the BBP 41a. When the transmission destination address information is contained, the controlling portion 30 determines whether or not the transmission destination address information matches an apparatus address of the base apparatus 10.

When transmission destination address information is contained in the received signal and matches the apparatus address (identification information that identifies an apparatus) of the base apparatus 10, the controlling portion 30 determines that the received signal is not a disturbing signal, but a signal transmitted from the display terminal 50 to the base apparatus 10. When the received signal is a radio wave of other than a communication radio wave of another wireless communication system and transmission destination address information is not contained in the received signal or when the received signal is a communication radio wave of another wireless communication system and transmission destination address information contained in the received signal, the controlling portion 30 determines that the received signal is a disturbing wave.

However, the system may be structured in a manner that when the received field strength of a received signal that the controlling portion 30 has determined that the received signal is a disturbing wave with reference to the detected result of the received field strength detecting portion 47a is as low as it can be ignored, in step 102, the controlling portion 30 determines that a disturbing wave does not exist on the unused channel.

When the controlling portion 30 has determined that a disturbing wave exists on the unused channel in step 102, the flow advances to step 103. In step 103, the controlling portion 30 determines whether or not another unused channel exists. When the controlling portion 30 has determined that another unused channel exists, the flow returns to step 102.

In step 102, in the same manner as described above, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel.

When the controlling portion 30 has determined that a disturbing wave does not exist on the unused channel in step 102, the flow advances to step 104. After the controlling portion 30 has set the unused channel as a communication channel in step 104, the flow advances to process routine 200. In process routine 200, the controlling portion 30 executes a mode setting process for the frequency band Ba.

In reality, in process routine 200 of the mode setting process for this frequency band Ba, practically, as will be described later with reference to Fig. 12 and Fig. 13, the controlling portion 30 detects received field strengths at transmission rates in order from higher transmission rates on the communication channel that has been set in step 104 of process routine 100. The controlling portion 30 sets the highest transmission rate that the received field strength reaches or exceeds a predetermined threshold value as a mode.

After the controlling portion 30 has executed process routine 200, the flow advances to step 105. In step 105, the controlling portion 30 determines whether or not a communication should start in the frequency band Ba. When the controlling portion 30 has determined that the communication should start in the frequency band Ba, the controlling portion 30 completes the setting process. The controlling portion 30 starts the communication in the mode (transmission rate) that has been set in process routine 200

on the communication channel that has been set in step 104.

When the controlling portion 30 has determined that an unused channel does not exist in the frequency band Ba in step 101, when the controlling portion 30 has determined that another unused channel does not exist (an unused channel free of a disturbing wave does not exist in the frequency band Ba) in step 103, or when the controlling portion 30 has determined that the communication should not start in the frequency band Ba (although an unused channel free of a disturbing wave exists in the frequency band Ba, the received field strengths at all the transmission rates do not exceed the threshold value) in step 105, the flow advances to step 111. In step 111, the controlling portion 30 determines whether or not an unused channel exists in the frequency band Bb (2.4 GHz band).

When the controlling portion 30 has determined that an unused channel exists in the frequency band Bb, the flow advances from step 111 to step 112. In step 112, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel in accordance with the detected result of the disturbing wave detecting portion 43b for the frequency band Bb.

In this case, the controlling portion 30 determines whether or not the signal received by the transmitting and receiving portion 45b is a disturbing wave and whether or not a disturbing wave exists on an unused channel in the same manner as step 102.

When the controlling portion 30 has determined that

a disturbing wave exists on the unused channel in step 112, the flow advances to step 113. In step 113, the controlling portion 30 determines whether or not another unused channel exists. When the controlling portion 30 has determined that another unused channel exists, the flow returns to step 112. In step 112, in the same manner as described above, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel.

When the controlling portion 30 has determined that a disturbing wave does not exist on the unused channel in step 112, the flow advances to step 114. In step 114, the controlling portion 30 sets the unused channel as a communication channel. Thereafter, the flow advances to process routine 300. In process routine 300, the controlling portion 30 executes a mode setting process for the frequency band Bb.

Practically, in process routine 300 of the mode setting process for the frequency band Bb, as will be described later with reference to Fig. 14, the controlling portion 30 detects a received field strength at the highest transmission rate on the communication channel that has been set in step 114 of process routine 100. When the received field strength reaches or exceeds the threshold value, the controlling portion 30 sets the transmission rate as a mode. When the received field strength does not reach the threshold value, the controlling portion 30 sets the next highest transmission rate as a mode.

When the controlling portion 30 has determined that

an unused channel does not exist in the frequency band Bb in step 111 or when the controlling portion 30 has determined that another unused channel does not exist (an unused channel free of a disturbing wave does not exist in the frequency band Bb), the flow advances to step 115. In step 115, the controlling portion 30 sets a predetermined radio channel in a predetermined frequency band as a communication channel and sets a predetermined mode (transmission rate). For example, the controlling portion 30 sets a particular radio channel in the frequency band Ba (5.2 GHz band) as a communication channel and sets mode A8 (transmission rate: 54 Mbps) as a mode of the transmission rate. Thereafter, the controlling portion 30 completes the setting process performed upon startup of communication and starts the communication.

However, step 115 of process routine 100 may be structured in a manner that the controlling portion 30 transmits a message that represents that data cannot be transmitted due to an improper communication environment from the base apparatus 10 to the display terminal 50 and causes the message to be displayed on the LCD 51 of the display terminal 50 or the message to be output as audio data from the speaker 55 so as to inform the user of the message.

[Mode setting process for frequency band Ba: Fig. 12 and Fig. 13]

Fig. 12 and Fig. 13 show an example of a process routine 200 of a mode setting process for the frequency band Ba (5.2 GHz band).

When the controlling portion 30 starts a communication

in process routine 200, first of all, in step 104 of process routine 100, the controlling portion 30 sets an unused channel free of a disturbing wave in the frequency band Ba as a communication channel. Thereafter, in step 211, the controlling portion 30 transmits a setup signal in mode A8 (transmission rate: 54 Mbps), which has the highest transmission rate in the frequency band Ba, from the base apparatus 10 to the display terminal 50.

Thereafter, the flow advances to step 212. In step 212, the controlling portion 30 determines whether or not the received field strength at the time reaches or exceeds the threshold value.

As an example of the method for detecting and determining the received field strength, the following method may be used. The transmitting and receiving portion 85a of the display terminal 50 receives a signal transmitted from the base apparatus 10. The received field strength detecting portion 87a of the display terminal 50 detects the received field strength. The controlling portion 70 of the display terminal 50 determines whether or not the received field strength reaches or exceeds the threshold value and transmits the result from the display terminal 50 to the base apparatus 10. The controlling portion 30 of the base apparatus 10 determines whether or not the received field strength reaches or exceeds the threshold value.

As another method, the following method may be used. When the display terminal 50 has received a signal transmitted from the base apparatus 10, the display terminal 50 transmits

an acknowledge signal that notifies the base apparatus 10 that the display terminal 50 has received the signal to the base apparatus 10. The transmitting and receiving portion 45a of the base apparatus 10 receives the acknowledge signal. The received field strength detecting portion 47a of the base apparatus 10 detects the received field strength. The controlling portion 30 of the base apparatus 10 determines whether or not the received field strength reaches or exceeds the threshold value.

When the controlling portion 30 has determined that the received field strength in mode A8 reaches or exceeds the threshold value in step 212, the controlling portion 30 completes the mode setting process for the frequency band Ba. When the controlling portion 30 starts the communication, the flow advances to step 105 of process routine 100. In step 105, the controlling portion 30 determines that the communication should start in the frequency band Ba. The controlling portion 30 starts the communication in mode A8 on the communication channel that has been set in step 104.

When the controlling portion 30 has determined that the received field strength in mode A8 does not reach the threshold value in step 212, the flow advances to step 221. In step 212, the controlling portion 30 transmits a setup signal in mode A7 (transmission rate: 48 Mbps), which has the second highest transmission rate in the frequency band Ba, from the base apparatus 10 to the display terminal 50. Thereafter, the flow advances to step 222. In step 222, the controlling portion 30 determines whether or not the received field strength at the time reaches or exceeds the threshold

value in the same method as described above.

Thereafter, when the controlling portion 30 has determined that the received field strength in mode A7 reaches or exceeds the threshold value in step 222, the controlling portion 30 completes the mode setting process for the frequency band Ba. When the controlling portion 30 starts the communication, the flow advances to step 105 of process routine 100. In step 105, the controlling portion 30 determines that the communication should start in the frequency band Ba and starts the communication in mode A7 on the communication channel that has been set in step 104.

When the controlling portion 30 has determined that the received field strength in mode A7 does not reach the threshold value in step 222, the flow advances to step 231. In step 231, the controlling portion 30 transmits a setup signal in mode A6 (transmission rate: 36 Mbps) from the base apparatus 10 to the display terminal 50. Thereafter, the flow advances to step 232. In step 232, the controlling portion 30 determines whether or not the received field strength at the time reaches or exceeds the threshold value in the same method as described above.

When the controlling portion 30 has determined that the received field strength in mode A6 reaches or exceeds the threshold value in step 232, the controlling portion 30 completes the mode setting process for the frequency band Ba. When the controlling portion 30 starts a communication in process routine 100, the controlling portion 30 starts the communication in mode A6 in the same manner as described

above.

When the controlling portion 30 has determined that the received field strength in mode A6 does not reach the threshold value in step 232, the flow advances to step 241. In step 241, the controlling portion 30 transmits a setup signal in mode A5 (transmission rate: 24 Mbps) from the base apparatus 10 to the display terminal 50. Thereafter, the flow advances to step 242. The controlling portion 30 determines whether or not the received field strength at the time reaches or exceeds the threshold value in the same method as described above.

When the controlling portion 30 has determined that the received field strength in mode A5 reaches or exceeds the threshold value in step 242, the controlling portion 30 completes the mode setting process for the frequency band Ba. When the controlling portion 30 starts a communication in process routine 100, the controlling portion 30 starts the communication in mode A5 in the same manner as described above.

When the controlling portion 30 has determined that the received field strength in mode A5 does not reach the threshold value in step 242, the flow advances to step 251. In step 251, the controlling portion 30 transmits a setup signal in mode A4 (transmission rate: 18 Mbps) from the base apparatus 10 to the display terminal 50. Thereafter, the flow advances to step 252. In step 252, the controlling portion 30 determines whether or not the received field strength at the time reaches or exceeds the threshold value in the same

method as described above.

When the controlling portion 30 has determined that the received field strength in mode A4 reaches or exceeds the threshold value in step 252, the controlling portion 30 completes the mode setting process for the frequency band Ba. When the controlling portion 30 starts a communication in process routine 100, the controlling portion 30 starts the communication in mode A4 in the same manner as described above.

When the controlling portion 30 has determined that the received field strength in mode A4 does not reach the threshold value in step 252, the flow advances to step 261. In step 261, the controlling portion 30 transmits a setup signal in mode A3 (transmission rate: 12 Mbps) from the base apparatus 10 to the display terminal 50. Thereafter, the flow advances to step 262. In step 262, the controlling portion 30 determines whether or not the received field strength at the time reaches or exceeds the threshold value in the same method as described above.

When the controlling portion 30 has determined that the received field strength in mode A3 reaches or exceeds the threshold value in step 262, the controlling portion 30 completes the mode setting process for the frequency band Ba. When the controlling portion 30 starts a communication in process routine 100, the controlling portion 30 starts the communication in mode A3 in the same manner as described above.

When the controlling portion 30 has determined that the received field strength in mode A3 does not reach the threshold value in step 262, the flow advances to step 271. In step 271, the controlling portion 30 transmits a setup signal in mode A2 (transmission rate: 9 Mbps) from the base apparatus 10 to the display terminal 50. Thereafter, the flow advances to step 272. The controlling portion 30 determines whether or not the received field strength at the time reaches or exceeds the threshold value in the same method as described above.

When the controlling portion 30 has determined that the received field strength in mode A2 reaches or exceeds the threshold value in step 272, the controlling portion 30 completes the mode setting process for the frequency band Ba. When the controlling portion 30 starts a communication in process routine 100, the controlling portion 30 starts the communication in mode A2 in the same manner as described above.

When the controlling portion 30 has determined that the received field strength in mode A2 does not reach the threshold value in step 272, the flow advances to step 281. In step 281, the controlling portion 30 transmits a setup signal in mode A1 (transmission rate: 6 Mbps), which has the lowest transmission rate in the frequency band Ba, from the base apparatus 10 to the display terminal 50. Thereafter, the flow advances to step 282. In step 282, the controlling portion 30 determines whether or not the received field strength at the time reaches or exceeds the threshold value in the same method as described above.

When the controlling portion 30 has determined that the received field strength in mode A1 reaches or exceeds the threshold value in step 282, the controlling portion 30 completes the mode setting process for the frequency band Ba. When the controlling portion 30 starts a communication in process routine 100, the controlling portion 30 starts the communication in mode A1 in the same manner as described above.

When the controlling portion 30 has determined that the received field strength in mode A1 does not reach the threshold value in step 282, the flow advances to step 291. In step 291, the controlling portion 30 has determined that any mode should not be set in the frequency band Ba and completes the mode setting process for the frequency band Ba. When the controlling portion 30 starts communication, the flow advances to step 105 of process routine 100. In step 105, the controlling portion 30 has determined that a communication should not start in the frequency band Ba. In this case, like the case when the controlling portion 30 has determined that an unused channel does not exist in the frequency band Ba in step 101 or when the controlling portion 30 has determined that an unused channel free of a disturbing wave does not exist in the frequency band Ba in step 103, the flow advances to step 111 in the same manner as described above, the flow advances to step 111.

When the communication environment does not vary, the received sensitivity point (the received field strength of which the bit error rate of the received data does not reach

a predetermined value) becomes high, as the transmission rate is increased. Therefore, the threshold values at the above-described steps 212, 222, 232, 242, 252, 262, 272, and 282 are increased as the transmission rate becomes high.

[Mode setting process for frequency band Bb: Fig. 14]

Fig. 14 shows an example of a process routine 300 of a mode setting process for the frequency band Bb (2.4 GHz band).

When the controlling portion 30 starts a communication in process routine 300, the flow returns to step 114 of process routine 100. In step 114, the controlling portion 30 sets an unused channel free of a disturbing wave in the frequency band Bb as a communication channel. Thereafter, the flow advances to step 311. In step 311, the controlling portion 30 transmits a setup signal in mode B4, which has the highest transmission rate in the frequency band Bb (transmission rate: 11 Mbps), from the base apparatus 10 to the display terminal 50 in step 311.

Thereafter, the flow advances to step 312. In step 312, the controlling portion 30 determines whether or not the received field strength at the time reaches or exceeds the threshold value.

As an example of the method for detecting and determining the received field strength, the following method may be used. The transmitting and receiving portion 85b of the display terminal 50 receives a signal transmitted from the base apparatus 10. The received field strength detecting

portion 87b of the display terminal 50 detects the received field strength. The controlling portion 70 of the display terminal 50 determines whether or not the received field strength reaches or exceeds the threshold value and transmits the result from the display terminal 50 to the base apparatus 10. The controlling portion 30 of the base apparatus 10 determines whether or not the received field strength reaches or exceeds the threshold value.

As another method, the following method may be used. When the display terminal 50 has received a signal transmitted from the base apparatus 10, the display terminal 50 transmits an acknowledge signal that notifies the base apparatus 10 that the display terminal 50 has received the signal to the base apparatus 10. The transmitting and receiving portion 45b of the base apparatus 10 receives the acknowledge signal. The received field strength detecting portion 47b of the base apparatus 10 detects the received field strength. The controlling portion 30 of the base apparatus 10 determines whether or not the received field strength reaches or exceeds the threshold value.

On the other hand, when the controlling portion 30 has determined that the received field strength in mode B4 reaches or exceeds the threshold value in step 312, the controlling portion 30 completes the mode setting process for the frequency band Bb. When the controlling portion 30 starts a communication, the controlling portion 30 starts the communication in mode B4 on the communication channel that has been set in step 114 of process routine 100.

When the controlling portion 30 has determined that the received field strength in mode B4 does not reach the threshold value in step 312, the flow advances to step 313. In step 313, the controlling portion 30 sets mode B3 (transmission rate: 5.5 Mbps), which has the second highest transmission rate in the frequency band Bb and completes the mode setting process for the frequency band Bb. When the controlling portion 30 starts a communication, the controlling portion 30 starts the communication in mode B3 on the communication channel that has been set in step 114 of process routine 100.

When the received field strength in mode B4 does not reach the threshold value, the controlling portion 30 sets mode B3 without determining whether or not the received field strength in mode B3 reaches or exceeds the threshold value, because when the received field strength in mode B3 did not exceed the threshold value, if the controlling portion 30 set mode B2 (transmission rate: 2 Mbps) or mode B1 (transmission rate: 1 Mbps), the obtained transmission rate would become too low.

However, process routine 300 may be structured in the following manner. When the controlling portion 30 has determined that the received field strength in mode B4 does not reach the threshold value in step 312, the controlling portion 30 transmits a setup signal in mode B3 to the display terminal 50 and then determines whether or not the received field strength in mode B3 reaches or exceeds the threshold value. When the received field strength reaches or exceeds the threshold value, the controlling portion 30 sets mode B3.

When the received field strength does not reach the threshold value, the controlling portion 30 determines that any mode should not be set in the frequency band Bb.

When the controlling portion 30 has determined that any mode should not be set in the frequency band Bb in process routine 300, in the same manner as the controlling portion 30 has determined that an unused channel exists in the frequency band Bb in step 111 or when the controlling portion 30 has determined that an unused channel free of a disturbing wave does not exist in the frequency band Bb in step 113, the flow advances to step 115. In step 115, the controlling portion 30 sets a predetermined radio channel of a predetermined frequency band as a communication channel, sets a predetermined mode (transmission rate), and starts the communication.

[Changing process performed during communication: Fig. 15 to Fig. 21]

(Changing process performed during normal communication: Fig. 15 to Fig. 18)

When the controlling portion 30 starts a communication at a high transmission rate in the frequency band Ba, if a disturbing wave takes place on a communication channel during the communication, it is desirable to change the communication channel. On the other hand, when the controlling portion 30 starts a communication at a low transmission rate in the frequency band Bb, if an unused channel takes place in the frequency band Ba during the communication, it is desirable to change the communication channel to the unused channel in the frequency band Ba so as

to increase the transmission rate.

Therefore, the above-described wireless communication system is structured in a manner that while the base apparatus 10 is communicating with the display terminal 50, the controlling portion 30 of the base apparatus 10 executes the following changing process.

<Changing process performed during communication in frequency band Ba: Fig. 15 and Fig. 16>

Fig. 15 and Fig. 16 show an example of a process routine of a changing process performed during communication in the frequency band Ba.

While the controlling portion 30 is communicating in the frequency band Bb, in step 129 of process routine 120, the controlling portion 30 periodically determines whether or not a disturbing wave exists on a communication radio channel in the frequency band Ba in accordance with the detected result of the disturbing wave detecting portion 43a for the frequency band Ba.

In this case, in the same manner as process routine 100 of the setting process performed upon startup of communication, when the controlling portion 30 determines whether or not a signal received by the transmitting and receiving portion 45a is a disturbing wave, the above-described method for detecting/identifying transmission destination address information is used.

When the controlling portion 30 has determined that

a disturbing wave exists on the communication radio channel in step 129, in the same manner as the controlling portion 30 starts a communication, first of all in step 121, the controlling portion 30 determines whether or not an unused channel exists in the frequency band Ba. When the controlling portion 30 has determined that an unused channel exists, the flow advances to step 122. In step 122, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel. When the controlling portion 30 has determined that a disturbing wave exists, the flow advances to step 123. In step 123, the controlling portion 30 determines whether or not another unused channel exists. When the controlling portion 30 has determined that an unused channel exists, the flow returns to step 122. In step 122, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel.

When the controlling portion 30 has determined that a disturbing wave does not exist on the unused channel in step 122, the flow advances to step 124. In step 124, the controlling portion 30 sets the unused channel as a communication channel. Thereafter, the flow advances to the above-described process routine 200. In process routine 200, the controlling portion 30 executes the mode setting process for the frequency band Ba. Thereafter, the flow advances to step 125. In step 125, the controlling portion 30 determines whether or not the communication should be continued in the frequency band Ba in accordance with the result of the execution of process routine 200. When the controlling portion 30 has determined that the communication should be continued in the frequency band Ba, the controlling portion

30 restores the communicating state in the frequency band Ba.

When the controlling portion 30 has determined that an unused channel does not exist in the frequency band Ba in step 121, when the controlling portion 30 has determined that another unused channel does not exist (an unused channel free of a disturbing wave does not exist in the frequency band Ba) in step 123, or when the controlling portion 30 has determined that the communication should not be continued in the frequency band Ba (although an unused channel free of a disturbing wave exists in the frequency band Ba, the received field strengths at all the transmission rates in the frequency band Ba do not exceed the threshold value) in step 125, the flow advances to step 131. In step 131, the controlling portion 30 determines whether or not an unused channel exists in the frequency band Bb.

When the controlling portion 30 has determined that an unused channel exists in the frequency band Bb, the flow advances from step 131 to step 132. In step 132, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel. When the controlling portion 30 has determined that a disturbing wave exists, the flow advances to step 133. In step 133, the controlling portion 30 determines whether or not another unused channel exists. When the controlling portion 30 has determined that another unused channel exists, the flow returns to step 132. In step 132, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel.

When the controlling portion 30 has determined that

a disturbing wave does not exist on the unused channel in step 132, the flow advances to step 134. In step 134, the controlling portion 30 sets the unused channel as a communication channel. Thereafter, the flow advances to the above-described process routine 300. In process routine 300, the controlling portion 30 executes the mode setting process for the frequency band Bb. The controlling portion 30 completes the changing process performed during communication in the frequency band Ba. Thereafter, the controlling portion 30 enters a communicating state in the frequency band Bb.

When the controlling portion 30 has determined that an unused channel does not exist in the frequency band Bb in step 131 or when the controlling portion 30 has determined that another unused channel does not exist (an unused channel free of a disturbing wave does not exist in the frequency band Bb) in step 133, the flow advances to step 135. In step 135, the controlling portion 30 continues the current communication for a predetermined time period and restores the communicating state in the frequency band Ba.

<Changing process performed during communication in frequency band Bb: Fig. 17 and Fig. 18>

Fig. 17 and Fig. 18 show an example of a process routine of a changing process performed during communication in the frequency band Bb.

In process routine 140, while the controlling portion 30 is communicating, in step 147, the controlling portion 30 periodically determines whether or not a disturbing wave

exists on a communication radio channel in accordance with the detected result of the disturbing wave detecting portion 43b for the frequency band Bb.

In this case, in the same manner as process routine 100 of the setting process performed upon startup of communication, when the controlling portion 30 determines whether or not a signal received by the transmitting and receiving portion 45b is a disturbing wave, the above-described method for detecting/identifying transmission destination address information is used.

When the controlling portion 30 has determined that a disturbing wave exists on the communication radio channel in step 147, the flow directly advances from step 147 to step 141. When the controlling portion 30 determines that the disturbing wave does not exist on the communication radio channel in step 147, the flow advances from step 147 to step 149. In step 149, the controlling portion 30 continues the current communication for a predetermined time period. Thereafter, the flow advances to step 141.

In step 141, the controlling portion 30 determines whether or not an unused channel exists in the frequency band Ba. When the controlling portion 30 has determined that an unused channel exists, the flow advances to step 142. In step 142, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel. When the controlling portion 30 has determined that a disturbing wave exists, the flow advances to step 143. In step 143, the controlling portion 30 determines whether or not another

unused channel exists. When the controlling portion 30 has determined that another unused channel exists, the flow returns to step 142. In step 142, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel.

When the controlling portion 30 has determined that a disturbing wave does not exist on the unused channel in step 142, the flow advances to step 144. In step 144, the controlling portion 30 sets the unused channel as a communication channel. Thereafter, the flow advances to the above-described process routine 200. In process routine 200, the controlling portion 30 executes a mode setting process for the frequency band Ba. Thereafter, the flow advances to step 145. In step 145, the controlling portion 30 determines whether or not the communication should be continued in the frequency band Ba. When the controlling portion 30 has determined that the communication should be continued in the frequency band Ba, the controlling portion 30 completes the changing process performed during communication in the frequency band Ba. Thereafter, the controlling portion 30 enters a communicating state in the frequency band Ba.

When the controlling portion 30 has determined that an unused channel does not exist in the frequency band Ba in step 141, when the controlling portion 30 has determined that another unused channel does not exist (an unused channel free of a disturbing wave does not exist in the frequency band Ba) in step 143, or when the controlling portion 30 has determined that the communication should not be continued in the frequency band Ba (although an unused channel free of a

disturbing wave exists in the frequency band Ba, the received field strengths at all the transmission rates in the frequency band Ba do not exceed the threshold value) in step 145, the flow advances to step 151. In step 145, the controlling portion 30 determines whether or not an unused channel exists in the frequency band Bb.

When the controlling portion 30 has determined that an unused channel exists in the frequency band Bb, the flow advances from step 151 to step 152. In step 152, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel. When the controlling portion 30 has determined that a disturbing wave exists, the flow advances to step 153. In step 153, the controlling portion 30 determines whether or not another unused channel exists. When the controlling portion 30 has determined that another unused channel exists, the flow returns to step 152. In step 152, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel.

When the controlling portion 30 has determined that a disturbing wave does not exist on the unused channel in step 152, the flow advances to step 154. In step 154, the controlling portion 30 sets the unused channel as a communication channel. Thereafter, the flow advances to the above-described process routine 300. In process routine 300, the controlling portion 30 executes the mode setting process for the frequency band Bb and restores the communicating state in the frequency band Bb.

When the controlling portion 30 has determined that

an unused channel does not exist in the frequency band Bb in step 151 or when the controlling portion 30 has determined that another unused channel does not exist (an unused channel free of a disturbing wave does not exist in the frequency band Bb) in step 153, the flow advances to step 155. In step 155, the controlling portion 30 sets for example a predetermined radio channel of a predetermined frequency band as a communication channel, sets a predetermined mode (transmission rate), and completes the changing process performed during communication in the frequency band Bb.

(Change of transmission rate: Fig. 19 to Fig. 21)

<In the case in which transmission rate is increased: Fig. 19>

When the controlling portion 30 starts a communication in the frequency band Ba, even if the transmission rate cannot be increased because the electric field is weak, if the environment of the electric field varies, the transmission rate may be increased. Thus, the system is structured so that in that case the transmission rate can be increased as follows.

Fig. 19 shows an example of a process routine of a mode changing process that the controlling portion 30 of the base apparatus 10 executes in that case.

In process routine 160, while the controlling portion 30 is communicating in the frequency band Ba, the controlling portion 30 periodically determines whether or not a mode having a higher transmission rate than the current mode exists. When a mode having a higher transmission rate than the current

mode does not exist, namely, while the controlling portion 30 is communicating in mode A8 (transmission rate: 54 Mbps), the flow advances to step 162. In step 162, the controlling portion 30 continues the communication in the current mode (transmission rate).

When a mode has a higher transmission rate than the current mode, namely, during communication in a mode lower than mode A7, the flow advances from step 161 to step 163. In step 163, the controlling portion 30 changes the current mode to a mode having a higher transmission rate. Thereafter, the flow advances to step 164. In step 164, the controlling portion 30 determines whether or not the received field strength at the changed transmission rate reaches or exceeds the threshold value.

When the received field strength at the changed transmission rate does not reach the threshold value, the flow advances from step 164 to step 165. In step 165, the controlling portion 30 restores the preceding mode (transmission rate) from which the transmission rate was changed in step 163 and continues the communication. When the received field strength at the changed transmission rate reaches or exceeds the threshold value, the flow advances from step 164 to step 166. In step 166, the controlling portion 30 determines whether or not a mode having a higher transmission rate than the current mode exists. When a mode having a higher transmission rate than the current mode exists, the flow returns to step 163. The controlling portion 30 executes steps after step 163. When a mode having a higher transmission rate than the current mode does not exist, the

flow advances to step 167. In step 167, the controlling portion 30 continues the communication in the mode (transmission rate) that was changed in step 163.

Therefore, for example, while the controlling portion 30 is communicating in mode A4, if the received field strength reaches or exceeds the threshold value in mode A5, but not in mode A6, the controlling portion 30 successively executes steps 161, 163, 164, 166, 163, 164, and 165. As a result, the controlling portion 30 changes mode A4 to mode A4.

In contrast, while the controlling portion 30 is communicating in mode A7, if the received field strength reaches or exceeds the threshold value in mode A8, the controlling portion 30 successively executes steps 161, 163, 164, 166, and 167. As a result, the controlling portion 30 changes mode A7 to mode A8.

<In the case in which transmission rate is decreased: Fig. 20 and Fig. 21>

In a good environment of a radio wave free of a disturbing wave, while the controlling portion 30 is communicating at a high transmission rate in the frequency band Ba, when the user having the display terminal 50 goes away from the base apparatus 10, the condition of an electric field varies because the distance between the base apparatus 10 and the display terminal 50 becomes large. In this case, the received field strength becomes lower than the received sensitivity point. As a result, the bit error rate of the received data becomes large. Thus, a communication cannot be securely performed. Thus, the system is structured so that

in that case the transmission rate is decreased and the received field strength becomes larger than the received sensitivity point.

Fig. 20 and Fig. 21 show an example of a process routine of a mode changing process that the controlling portion 30 of the base apparatus 10 executes in that case.

In process routine 180, while the controlling portion 30 is communicating in the frequency band Ba, the controlling portion 30 periodically determines whether or not the received field strength at the current transmission rate reaches or exceeds the received sensitivity point in step 181. When the received field strength reaches or exceeds the received sensitivity point, the flow advances to step 182. In step 182, the controlling portion 30 continues the communication in the current mode (transmission rate).

When the received field strength at that transmission rate does not reach the received sensitivity point, the flow advances from step 181 to step 183. In step 183, the controlling portion 30 determines whether or not a mode having a lower transmission rate than the current mode exists. When a mode having a lower transmission rate exists, the flow advances from step 183 to step 184. In step 184, the controlling portion 30 changes the current mode to a mode having a lower transmission rate by one level. Thereafter, the flow advances to step 185. In step 185, the controlling portion 30 determines whether or not the received field strength at the changed transmission rate reaches or exceeds the received sensitivity point.

When the received field strength at the changed transmission rate reaches or exceeds the received sensitivity point, the flow advances from step 185 to step 186. In step 186, the controlling portion 30 continues the communication in the mode (transmission rate) changed in step 184. When the received field strength at the changed transmission rate does not reach the received sensitivity point, the flow advances from step 185 to step 187. In step 187, the controlling portion 30 determines whether or not a mode having a lower transmission rate than the current mode exists. When a mode having a lower transmission rate than the current mode exists, the flow returns to step 184. The controlling portion 30 repeats steps from step 184.

Therefore, while the controlling portion 30 is communicating in for example mode A4, when the received field strength does not reach the received sensitivity point, if the received field strength reaches or exceeds the received sensitivity point in mode A3, the controlling portion 30 successively executes steps 181, 183, 184, 185, and 186. As a result, the controlling portion 30 changes mode A4 to mode A3.

In contrast, when the controlling portion 30 has determined that a mode having a lower transmission rate than the current mode does not exist in step 183, namely, while the controlling portion 30 is communicating in mode A1, if the received field strength does not reach the received sensitivity point, or when the controlling portion 30 has determined that a mode having a lower transmission rate than

the current mode does not exist in step 187, namely even if the controlling portion 30 decreases the transmission rate to mode A1, if the received field strength does not reach the received sensitivity point, the flow advances to step 191. In step 191, the controlling portion 30 determines whether or not an unused channel exists in the frequency band Bb.

When the controlling portion 30 has determined that an unused channel exists in the frequency band Bb, the flow advances from step 191 to step 192. In step 192, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel. When the controlling portion 30 has determined that a disturbing wave exists, the flow advances to step 193. In step 193, the controlling portion 30 determines whether or not anther unused channel exists. When the controlling portion 30 has determined that another unused channel exists, the flow returns to step 192. In step 192, the controlling portion 30 determines whether or not a disturbing wave exists on the unused channel.

When the controlling portion 30 has determined that a disturbing wave does not exist on the unused channel in step 192, the flow advances to step 194. In step 194, the controlling portion 30 sets the unused channel as a communication channel. Thereafter, the flow advances to above-described process routine 300. In process routine 300, the controlling portion 30 executes the mode setting process for the frequency band Bb and completes the mode changing process. Thereafter, the controlling portion 30 enters a communicating state in the frequency band Bb.

When the controlling portion 30 has determined that an unused channel does not exist in the frequency band Bb in step 191 or when the controlling portion 30 has determined that another unused channel does not exist (an unused channel free of a disturbing wave does not exist in the frequency band Bb) in step 193, the flow advances to step 195. In step 195, the controlling portion 30 continues the communication in mode A1 having the lowest transmission rate on the original communication channel in the frequency band Ba, thus, having the highest possibility of which the received field strength reaches or exceeds the received sensitivity point.

[Other embodiments]

Frequency bands that have been currently defined in the IEEE standard and domestic standard are only 5.2 GHz band (5 GHz band) and 2.4 GHz band. However, it is technically possible to use other frequency bands as radio frequency bands. There is a possibility of which other frequency bands will be defined in future. Thus, the two frequency bands are not limited to 5.2 GHz band (5 GHz band) and 2.4 GHz band. In addition, the present invention can be applied to the case in which three or more frequency bands are used.

In addition, the wireless communication apparatuses that compose the wireless communication system are not limited to the above-described base apparatus and display terminal.

Industrial Applicability

As described above, according to the present invention, in a wireless communication system that deals with a plurality

of communicable frequency bands having different transmission rates, a large volume of data can be securely and smoothly transmitted on real time basis without a disturbance of another wireless communication system and so forth and abnormalities of stop of a moving picture and a disturbance of a picture.